A water heat exchanger exchanges heat between a refrigerant and water, and includes a pair of flat refrigerant pipes and a flat water pipe. Each flat refrigerant pipe has a plurality of refrigerant passageway holes. The flat water pipe has at least one water passageway hole. The number of water passageway holes is fewer than the number of refrigerant passageway holes of the flat refrigerant pipes. Long side surfaces of the flat water pipe and a long side surface of each of the pair of flat refrigerant pipes are in tight contact with each other as viewed in cross section. The flat water pipe is interposed by the pair of flat refrigerant pipes.
FIG. 5
FIG. 9
FIG. 10
PORTION JOINED BY ELECTRO-RESISTANCE WELDING

FIG. 12
WATER HEAT EXCHANGER AND HOT WATER HEAT SOURCE APPARATUS

TECHNICAL FIELD

[0001] The present invention relates to a water heat exchanger that exchanges heat between a refrigerant and water.

BACKGROUND ART

[0002] In the conventional art, among refrigeration apparatuses within heat pump type hot water supply apparatuses, those that comprise a compression type refrigerant circuit are widely used. A refrigerant circuit uses, for example, CO₂ as the refrigerant and comprises a water heat exchanger. The water heat exchanger comprises a refrigerant pipe, wherein the refrigerant flows, and a water pipe, wherein the water flows; furthermore, heat is exchanged between these fluids by disposing their pipes such that they are opposed to one another. Specifically, the water is heated by exchanging heat between the high temperature and high pressure refrigerant and the liquid refrigerant and the low temperature and low pressure water. As a result, it is possible to output high temperature water by taking advantage of the characteristics of CO₂ in the supercritical region.

[0003] As an example of the conventional art of water heat exchangers, a structure is known, as disclosed in U.S. Patent No. 2004-218946, wherein a flat pipe is used as the water pipe and, furthermore, multiple refrigerant pipes are brought into tight contact with one another.

SUMMARY OF THE INVENTION

<Technical Problem>

[0004] However, in the art disclosed in U.S. Patent No. 2004-218946, in a working example 1, a large portion of the water pipe (i.e., at least half the surface of the water pipe) does not contact the refrigerant pipe, and consequently there is a risk that the heat of the water flowing through the water pipe, which was obtained from the refrigerant, will dissipate externally. In addition, while in a working example 2 of the Patent Document 1 (i.e., Japanese Unexamined Patent Application Publication No. 2004-218946), the water pipe has a cross shaped cross section and is brought into tight contact with four refrigerant pipes disposed therearound, and therefore a smaller portion of the water pipe than in the working example 1 does not contact the refrigerant pipes, the number of components is greater than in the working example 1, and therefore the structure is more complicated. Consequently, the manufacture of the heat exchanger according to the working example 2 is not simple and is more costly.

[0005] An object of the present invention is to provide a water heat exchanger that can efficiently exchange heat between water and a refrigerant and that is simple to manufacture.

<Solution to Problem>

[0006] A water heat exchanger according to a first aspect of the invention is a water heat exchanger that exchanges heat between a refrigerant and water and comprises a pair of refrigerant pipes and a water pipe. The pair of refrigerant pipes each are a many holed flat pipe that has a plurality of refrigerant passageway holes therethrough the refrigerant can flow. The water pipe is a sparely holed flat pipe. The sparely holed flat pipe, therethrough the water can flow, has fewer water passageway holes than the refrigerant pipes have refrigerant passageway holes. Furthermore, in a cross section, the long side surfaces of the water pipe and one of the long side surfaces of each of the pair of refrigerant pipes are in tight contact with one another. Furthermore, the water pipe is interposed by the pair of refrigerant pipes.

[0007] The water heat exchanger of the present invention is configured such that the water pipe is interposed by the pair of the refrigerant pipes. Furthermore, in a cross section, the long side surfaces of the water pipe interposed by the pair of the refrigerant pipes and one of the long side surfaces of each of the refrigerant pipes are in tight contact with another.

[0008] Thus, because configuring the water heat exchanger in this manner brings most of the periphery of the water pipe into tight contact with the refrigerant pipes, it is possible to maximally prevent any heat transmitted to the water from the refrigerant from being transmitted to any substance surrounding the water heat exchanger (e.g., the air around the water heat exchanger). In addition, because the pair of refrigerant pipes and the water pipe are brought into tight contact with one another along their long side surfaces, which are flat surfaces, in a cross section, the configuration is simple and assembly is easy.

[0009] In addition, because the water heat exchanger of the present invention comprises the many holed flat pipe wherein the refrigerant pipe has a plurality of the refrigerant passageway holes, the coefficient of heat transfer on the refrigerant side can be increased by reducing the pipe diameter.

[0010] A water heat exchanger according to a second aspect of the invention is the water heat exchanger according to the first aspect of the invention, wherein the number of the water passageway holes of the sparely holed flat pipe is one or two.

[0011] In the water heat exchanger of the present invention, the number of the water passageway holes formed inside the sparely holed flat pipe, which is the water pipe, is one or two. Thus, reducing the number of the water passageway holes to one or two makes it possible to simplify the formation of the sparely holed flat pipe and to adopt, for example, various methods as needed to form the sparely holed flat pipe.

[0012] A water heat exchanger according to a third aspect of the invention is the water heat exchanger according to the first or second aspect of the invention, wherein the water pipe and each of the pair of refrigerant pipes are joined by brazing using a brazing filler material or by adhesives.

[0013] In the water heat exchanger of the present invention, in a cross section, the long side surfaces of the water pipe and one of the long side surfaces of the pair of refrigerant pipes are joined to one another (i.e., their flat surfaces are joined to one another) by brazing or by the application of the adhesive. Accordingly, it is possible to achieve a state wherein there is virtually no thermal resistance caused by the contact between the pair of refrigerant pipes and the water pipe. Consequently, the heat exchanging efficiency between the refrigerant and the water can be improved.

[0014] A water heat exchanger according to a fourth aspect of the invention is the water heat exchanger according to any one aspect of the first through third aspects of the invention, wherein the refrigerant pipes and/or the water pipe is formed by drawing or extruding.
Accordingly, the refrigerant pipes or the water pipe, or both, can be formed easily.

A water heat exchanger according to a fifth aspect of the invention is the water heat exchanger according to any one aspect of the first through fourth aspects of the invention, wherein the sparsely holed flat pipe is formed by bending a flat plate.

In the water heat exchanger of the present invention, the sparsely holed flat pipe is formed by bending the flat plate. For example, the flat pipe is formed after the flat plate is fabricated into a pipe shape by bending.

Accordingly, the flat pipe can be formed after performing some kind of fabrication (e.g., drilling, embossing, or forming a multilayer structure of different materials) on the flat plate. Namely, the prescribed fabrication can be performed easily on the sparsely holed flat pipe.

A water heat exchanger according to a sixth aspect of the invention is the water heat exchanger according to the fifth aspect of the invention, wherein the sparsely holed flat pipe is an electro-resistance welded pipe that is formed by bringing two sides of the flat plate into contact by the bending, and then joining the two sides.

In the water heat exchanger of the present invention, the sparsely holed flat pipe is formed as a member whose cross section is C shaped by bending the flat plate so that the two sides that constitute the end parts of the flat plate mate with one another. Furthermore, subsequently, the pipe shaped member is formed by joining (e.g., by electro-resistance welding or brazing) the two mated sides.

Accordingly, the flat pipe can be formed after performing some kind of fabrication (e.g., embossing, drilling, or forming a multilayer structure of different materials) on the flat plate. Thereby, it is possible to make, for example, the axial cross sectional shape of the sparsely holed flat pipe (particularly the shape of the inner surface of the sparsely holed flat pipe) into a shape that varies with its position in the direction of water flow. Consequently, turbulence can be created in the flow of water inside the sparsely holed flat pipe, which makes it possible to improve the coefficient of heat transfer. In addition, for example, it is possible to easily perform a corrosion prevention process on the interior of the sparsely holed flat pipe. Consequently, corrosion of the sparsely holed flat pipe owing to water can be prevented.

A water heat exchanger according to a seventh aspect of the invention is the water heat exchanger according to the fifth or sixth aspect of the invention, wherein the flat plate is embossed prior to the bending.

In the water heat exchanger of the present invention, the sparsely holed flat pipe is formed by bending the flat plate. Furthermore, the flat plate can be embossed before the bending.

Accordingly, the flat pipe can be formed after the embossing of the flat plate. Thereby, it is possible to make, for example, the axial cross sectional shape of the sparsely holed flat pipe (particularly the shape of the inner surface of the sparsely holed flat pipe) into a shape that varies with its position in the direction of water flow. Consequently, turbulence can be created in the flow of water inside the sparsely holed flat pipe, which promotes water convection; furthermore, the sparsely holed flat pipe can be shaped so as to promote heat exchange efficiency.

A water heat exchanger according to an eighth aspect of the invention is the water heat exchanger according to any one aspect of the first through seventh aspects of the invention, wherein the refrigerant that flows through the interior of the refrigerant pipes and the water that flows through the interior of the water pipe flow in mutually opposing directions.

Accordingly, it is possible to secure a temperature differential between the refrigerant and the water. In addition, the temperature differential between the refrigerant and the water can be made nearly uniform over the entire water heat exchanger, which can improve heat exchanging efficiency, particularly if, as in the case wherein the refrigerant is a supercritical refrigerant, temperature changes occur over the entire heat exchanging area and the temperature at the beginning of the heat exchanger and the temperature at the end of the heat exchanger differ greatly.

A water heat exchanger according to a ninth aspect of the invention is the water heat exchanger according to any one aspect of the first through eighth aspects of the invention, wherein the refrigerant is CO$_2$.

In the present invention, CO$_2$ refrigerant is used as the refrigerant. CO$_2$ refrigerant is a so-called supercritical refrigerant wherein the high pressure side in the refrigeration cycle is in the supercritical region. For example, if the water heat exchanger of the present invention is adapted to a heat pump type water heater, then the water heat exchanger functions as a radiator. Unlike the use of a fluorocarbon based refrigerant, the use of a supercritical refrigerant gives rise to temperature changes over the entire area inside the water heat exchanger; consequently, if, for example, the vicinity of the outlet of the water pipe contacts the center part of the refrigerant pipe, then the refrigerant temperature at that portion might decrease to a temperature lower than the temperature in the vicinity of the outlet of the water, leading to a heat loss.

In the water heat exchanger of the present invention, a structure is adopted wherein the single sparsely holed flat pipe is interposed by the two many holed flat pipes. Consequently, there is hardly any difference between the temperature of the refrigerant inside one of the many holed flat pipes and the temperature of the refrigerant inside the other many holed flat pipe, which makes it possible to produce high temperature water with hardly any drop in the heat exchanging efficiency between the refrigerant and the water.

In addition, the global warming coefficient of CO$_2$ refrigerant is 1, which is approximately several hundred to ten thousand times far lower than that of conventional refrigerants, for example, fluorocarbon refrigerant.

Thus, the use of CO$_2$ refrigerant, which carries only a small environmental load, can help to reduce degradation of the global environment.

A hot water heat source apparatus according to a tenth aspect of the invention is a hot water heat source apparatus that uses a refrigerant circuit, which uses a supercritical refrigerant wherein the high pressure side of a refrigeration cycle is in the supercritical region, and that comprises: a compressor, a water heat exchanger, an expansion mechanism, and an evaporator. The compressor compresses the supercritical refrigerant. The water heat exchanger cools the supercritical refrigerant and heats water by exchanging heat between the water and the high temperature and high pressure supercritical refrigerant compressed by the compressor. The expansion mechanism reduces the pressure of the supercritical refrigerant cooled by the water heat exchanger. The evaporator evaporates the refrigerant whose pressure was reduced by the expansion mechanism. The water heat exchanger comprises a pair of refrigerant pipes, a water pipe, a refrigerant
inlet header, and a refrigerant outlet header. The pair of refrigerant pipes each are a many holed flat pipe. Each of the many holed flat pipe has a plurality of refrigerant passageway holes where through the refrigerant can flow. The water pipe is a sparely holed flat pipe. The sparely holed flat pipe, where through the water can flow, has fewer water passageway holes than the refrigerant pipes have refrigerant passageway holes. The inlets of the pair of refrigerant pipes are connected to the refrigerant inlet header. The outlets of the pair of refrigerant pipes are connected to the refrigerant outlet header. In a cross section, the long side surfaces of the water pipe and one of the long side surfaces of each of the pair of refrigerant pipes are in tight contact with one another. The water pipe is interposed by the pair of refrigerant pipes. The refrigerant that flows through the interior of the refrigerant pipes and the water that flows through the interior of the water pipe flow in mutually opposing directions.

In the hot water heat source apparatus of the present invention, the working refrigerant is a so-called supercritical refrigerant, wherein the high pressure side in the refrigeration cycle is in the supercritical region. For example, if the water heat exchanger of the present invention is adapted to a heat pump type water heater, then the water heat exchanger functions as a radiator. Unlike the use of a fluorocarbon based refrigerant, the use of a supercritical refrigerant gives rise to temperature changes over the entire area of the water heat exchanger.

In the hot water heat source apparatus of the present invention, a structure is adopted wherein the single sparely holed flat pipe is interposed between the two many holed flat pipes. In the pair of refrigerant pipes, the refrigerant flows from the inlet of the refrigerant inlet header into the inlets of the pair of refrigerant pipes, passes through the outlets of the pair of refrigerant pipes, and then flows out from the refrigerant outlet header. The refrigerant that flows through the interior of the refrigerant pipes and the water that flows through the interior of the water pipe flow in mutually opposing directions. The inlets of the many holed flat pipes, which are the pair of refrigerant pipes, are both connected to the refrigerant inlet header.

Accordingly, it is possible to exchange heat between the high temperature refrigerant, which flows from the refrigerant inlet header into the pair of the refrigerant pipes, and the water inside the water pipe. Consequently, unlike the case wherein, for example, one refrigerant pipe that has been folded into a zigzag and one water pipe are combined, the amount of heat dissipated from the water pipe into the atmosphere is small and virtually no temperature differences arise in the refrigerant on both sides of the water pipe, which makes it possible to obtain high temperature water efficiently.

**ADVANTAGEOUS EFFECTS OF INVENTION**

In the water heat exchanger according to the first through third aspects of the invention, the heat exchanging efficiency between the refrigerant and the water can be improved.

In the water heat exchanger according to the fourth aspect of the invention, the refrigerant pipes or the water pipe, or both, can be formed easily.

In the water heat exchanger according to the fifth aspect of the invention, the prescribed fabrication can be performed easily on the sparely holed flat pipe.

In the water heat exchanger according to the sixth aspect of the invention, the flat pipe can be formed after performing some kind of fabrication on the flat plate.

In the water heat exchanger according to the seventh aspect of the invention, turbulence can be created in the flow of water inside the sparely holed flat pipe, which promotes water convection; furthermore, the sparely holed flat pipe can be shaped so as to promote heat exchange efficiency.

In the water heat exchanger according to the eighth aspect of the invention, it is possible to secure a temperature differential between the refrigerant and the water.

In the water heat exchanger according to the ninth aspect of the invention, the use of CO₂ refrigerant, which carries only a small environmental load, can help to reduce degradation of the global environment.

In the water heat exchanger according to the tenth aspect of the invention, it is possible to obtain high temperature water efficiently.

**BRIEF DESCRIPTION OF THE DRAWINGS**

Fig. 1 is a system diagram of a heat pump type hot water supplying apparatus that comprises a refrigeration apparatus according to a first embodiment.

Fig. 2 is a cross sectional view that shows the internal structure of the refrigeration apparatus.

Fig. 3 is a block diagram of a control apparatus of the refrigeration apparatus.

Fig. 4 is an oblique view that shows the configuration of a water heat exchanger of the refrigeration apparatus.

Fig. 5(a) is a schematic diagram that shows a portion of a refrigerant inlet header and a water outlet header of the water heat exchanger.

Fig. 5(b) is a schematic diagram that shows a portion of a refrigerant outlet header and a water inlet header of the water heat exchanger.

Fig. 6 is a cross sectional view of the water heat exchanger.

Fig. 7 is a schematic diagram of a water heat exchanger joining method.

Fig. 8 is an internal piping diagram of the water heat exchanger according to a modified example (1).

Fig. 9 is a schematic diagram of a water heat exchanger joining method according to a modified example (4).

Fig. 10 is a cross sectional view of the water heat exchanger according to a modified example (7).

Fig. 11 is a diagram that shows a process of forming protruding parts by embossing a flat plate according to a modified example (8).

Fig. 12 is a diagram that shows a process of forming a single hole flat pipe by bending the flat plate formed with the protruding parts according to the modified example (8).

Fig. 13 is a diagram that shows a process of forming a single hole flat pipe by bending the flat plate formed with the protruding parts according to a modified example (9).

Fig. 14 is a schematic diagram of a water heat exchanger joining method according to a modified example (10).
FIG. 15 is a hot water circulation system that comprises a refrigeration apparatus according to a second embodiment.

DESCRIPTION OF EMBODIMENTS

First Embodiment

FIG. 1 shows a system of a heat pump type hot water supplying apparatus that comprises a refrigeration apparatus according to a first embodiment. A heat pump type hot water supplying apparatus comprises a refrigeration apparatus, which is a hot water heat source apparatus, and a hot water storage apparatus. The refrigeration apparatus comprises a compression type refrigerant circuit wherein a compressor, refrigerant pipes inside a water heat exchanger, an expansion valve that serves as a pressure reducing means, and an air heat exchanger are connected in a ring by a refrigerant piping.

Furthermore, a gas heat exchanger, which is for exchanging heat between a high pressure and high temperature refrigerant that exits the water heat exchanger and a low pressure and low temperature refrigerant that exits the air heat exchanger, is disposed in the refrigerant circuit. Specifically, heat is exchanged between a refrigerant passage that links the water heat exchanger and the expansion valve and a refrigerant passage that links the air heat exchanger and the compressor.

The hot water storage apparatus comprises a water circulation circuit, wherein a hot water storage tank, a water pipe inside the water heat exchanger, and a water circulating pump are connected in a ring by a water piping.

The refrigeration apparatus is provided with an outdoor air temperature sensor, which detects the outdoor air temperature of the installation location, a discharge pipe temperature sensor, which detects the discharge pipe temperature of the compressor, and a temperature sensor, which detects the temperature of the air heat exchanger; furthermore, the detection signals of these sensors are input to a microcontroller.

The water circulating pump controls the amount of circulation of the water such that the temperature of the water heated by the water heat exchanger is, for example, 85°C. The microcontroller controls the opening degree of the expansion valve to secure the refrigerant temperature needed to obtain water of 85°C.

<Controlling the Operation of the Refrigeration Apparatus>

FIG. 3 is a control block diagram of the refrigeration apparatus. In the microcontroller, a target discharge pipe temperature setting unit sets a target discharge pipe temperature based on detection signals from the outdoor air temperature sensor and the temperature sensor of the air heat exchanger. Furthermore, the microcontroller controls the opening degree of the expansion valve via an expansion valve opening degree control unit such that the discharge pipe temperature detected by the discharge pipe temperature sensor approaches the target discharge pipe temperature. Furthermore, data needed to set the target discharge pipe temperature is pre-stored inside the target discharge pipe temperature setting unit.

Furthermore, the microcontroller controls the operating frequency of the compressor via an inverter control unit, taking into consideration the effect that the outdoor air temperature has upon the fire-up capability of the refrigeration apparatus as well as the fact that the hot water supply load varies with the time of day. For example, to prevent hot water from running out at a time when the outdoor air temperature is low and the hot water supply load is large, the operating frequency of the compressor is increased, ignoring efficiency. Moreover, at a time when the outdoor air temperature is high and the hot water supply load is small, the operating frequency of the compressor may be set to a high efficiency point.

When the hot water supply load is large, the microcontroller controls the operation of the compressor such that, with a view toward protecting the compressor, the discharge pipe temperature does not exceed 120°C. In actuality, when the discharge pipe temperature is 120°C, the internal temperature of the compressor reaches 140-145°C; furthermore, if the internal temperature rises and exceeds 150°C, the magnetic force of the internal magnet of the compressor will decrease and the oil will deteriorate, leading to a breakdown. Accordingly, in the present embodiment, the upper limit of the discharge pipe temperature is set to 120°C.

However, when an outdoor air temperature is equal to or less than -20°C, the compressor tends to become overloaded; therefore, as an additional safety measure, it is necessary to set an ample amount of compensation for the detection value of the discharge pipe temperature sensor and to set the detection value of the discharge pipe temperature sensor 9 to 120°C before the actual discharge pipe temperature reaches 120°C. Accordingly, the amount of compensation for when the outdoor air temperature is equal to or less than -20°C is derived empirically, and is stored in a second compensating means of a temperature compensating unit of the microcontroller.
Furthermore, a first compensating means 61a performs compensation when the outdoor air temperature t1 > -20°C.

<Structure of Water Heat Exchanger>

**FIG. 4** is an oblique view that shows the configuration of the water heat exchanger 22. In this figure, the water heat exchanger 22 is represented schematically.

The water heat exchanger 22 comprises the refrigerant pipes 22a, the water pipe 22b, a refrigerant inlet header 53, a refrigerant outlet header 54, a water inlet header 55, and a water outlet header 56. The water heat exchanger 22 exchanges heat between the fluid that flows through the refrigerant pipes 22a and the fluid that flows through the water pipe 22b. As a specific structure, the water heat exchanger 22 principally comprises: a pair of many holed flat pipes 41A, 41B, which constitutes the refrigerant pipes 22a; a single hole flat pipe 42, which serves as a sparsely holed flat pipe that constitutes the water pipe 22b; the refrigerant inlet header 53, the refrigerant outlet header 54, the water inlet header 55, and the water outlet header 56.

**FIG. 5(a)** is a schematic diagram that shows a portion of the refrigerant inlet header 53 and the water outlet header 56 of the water heat exchanger 22. **FIG. 5(b)** is a schematic diagram that shows a portion of the refrigerant outlet header 54 and the water inlet header 55 of the water heat exchanger 22. As shown in **FIG. 5(a)**, in the water heat exchanger 22, the refrigerant inlet header 53 is connected to inlet sides of the refrigerant pipes 22a, and the refrigerant outlet header 54 is connected to outlet sides of the refrigerant pipes 22a. In addition, as shown in **FIG. 5(b)**, in the water heat exchanger 22, the water inlet header 55 is connected to an inlet side of the water pipe 22b, and the water outlet header 56 is connected to an outlet side of the water pipe 22b. In the water heat exchanger 22 of the present embodiment, the water heat exchanger 22 shown in **FIG. 4** is stacked in three stages (not shown) and each of the headers 53-56 extends in its axial directions.

As shown in **FIG. 6**, each of the many holed flat pipes 41A, 41B comprises a flat part main body 46. Each of the flat part main bodies 46 extends lengthwise, as shown in **FIG. 4**. Each of the flat part main bodies 46 has an opposing surface 46a and an opposite side surface 46b on the opposite side of the opposing surface 46a; furthermore, the opposing surface 46a and the opposite side surface 46b oppose one another. Inside each of the flat part main bodies 46, a plurality of (in the present embodiment, 11) refrigerant passageway holes 47, which are holes through which the refrigerant can flow, is formed in one row. Making the refrigerant pipe by forming a plurality of holes in a flat pipe in this manner improves the coefficient of heat transfer on the refrigerant side.

Each of the many holed flat pipes 41A, 41B is made of, for example, aluminum. Furthermore, the many holed flat pipes 41A, 41B may be manufactured by drawing, extruding, and the like.

The single hole flat pipe 42 is a member that extends along the pair of the many holed flat pipes 41A, 41B; as can be seen in the figure, in a cross section the single hole flat pipe 42 comprises two opposing linear portions 42a and two curved portions 42b, which connect the two linear portions 42a. Furthermore, it also comprises one water passageway hole 48, which is different from the many holed flat pipes 41A, 41B and wherethrough the water is capable of flowing. The length of the linear portions 42a is the same as that of the opposing surfaces 46a.

**FIG. 7** shows that the many holed flat pipes 41A, 41B and the single hole flat pipe 42 are brought into tight contact with one another by brazing, wherein brazing filler material 49 is interposed between the single hole flat pipe 42 and each of the many holed flat pipes 41A, 41B. Thereby, most of the surface of the single hole flat pipe 42 (i.e., most of the linear portions 42a) can be brought into tight contact with the many holed flat pipes 41A, 41B, which makes it possible to maximally prevent the dissipation of heat from the single hole flat pipe 42 to the surrounding air.

As shown in **FIG. 4**, the pair of many holed flat pipes 41A, 41B is folded into a zigzag shape such that the zigs and the zags are parallel to one another. For example, in **FIG. 4**, zigzag shape refers to a shape wherein the linear portions that extend linearly and the bent portions that are bent in a hairpin shape alternate repeatedly and, as a result, the plurality of the linear portions are disposed such that they are proximate to one another. In other words, the plurality of the linear portions are disposed such that they overlap one another. Thus, a compact structure can be achieved because the overall shape of the water heat exchanger 22 is a zigzag.

In the water heat exchanger 22, CO2 flows inside the refrigerant pipes 22a, and water flows inside the water pipe 22b in a direction that opposes that of the CO2 (refer to the solid arrows and the broken arrow, respectively, in **FIG. 5**). As a result, heat is exchanged between the fluids flowing therethrough, and thereby the water is heated. Here, because the heat transfer area is enlarged by the use of flat pipes, the heat exchange performance is high.

In addition, the linear portions of each of the many holed flat pipes 41A, 41B are adjacent to one another in the stacking directions; however, gaps 43 are established therebetween. The size of the gaps 43 is set such that heat is not exchanged between portions of adjacent flat pipes (i.e., between pipes of differing temperatures) owing to heat conduction. Thereby, the overall heat exchanging efficiency of the water heat exchanger 22 does not decline and, as a result, the water heat exchanger 22 can output hot water of a high temperature. In addition, the effects of thermal deformation can be reduced and, consequently, reliability is improved.

<Characteristics>

**FIG. 8** (1)

The water heat exchanger 22 of the present embodiment is configured such that the single hole flat pipe 42 is interposed by the pair of the many holed flat pipes 41A, 41B. Furthermore, in a cross section, the long side surfaces of the single hole flat pipe 42 interposed by the pair of the many holed flat pipes 41A, 41B are in tight contact with the many holed flat pipes 41A, 41B. Furthermore, the many holed flat pipes 41A, 41B and the single hole flat pipe 42 are joined by brazing or by coating with an adhesive.

**FIG. 9**

Thus, because configuring the water heat exchanger brings most of the periphery of the single hole flat pipe 42 into tight contact with the many holed flat pipes 41A, 41B, it is possible to maximally prevent any heat transmitted to the water from the refrigerant from being transmitted to any substance surrounding the water heat exchanger (e.g., the air around the water heat exchanger). In addition, because the
pair of many holed flat pipes 41A, 41B and the single hole flat pipe 42 are brought into tight contact with one another along their long side surfaces, which are flat surfaces, in a cross section, the configuration is simple and assembly is easy. In addition, because the pair of many holed flat pipes 41A, 41B and the single hole flat pipe 42 are joined by brazing, it is possible to create a state wherein there is virtually no thermal resistance between the pair of the many holed flat pipes 41A, 41B and the single hole flat pipe 42. Consequently, the heat exchanging efficiency between the refrigerant and the water can be improved.

(2)

In the water heat exchanger 22 of the present embodiment, CO₂, which is a supercritical refrigerant, is used as the working refrigerant. If a supercritical refrigerant like CO₂ refrigerant is used in the heat pump type hot water supplying apparatus 1, then the water heat exchanger 22 will function as a radiator. Unlike the temperature of a fluorocarbon based refrigerant, the temperature of CO₂ refrigerant varies over the entire area of the water heat exchanger. In addition, in the water heat exchanger 22 of the present embodiment, the structure wherein the singular single hole flat pipe 42 is interposed by the two many holed flat pipes 41A, 41B is connected in parallel by the headers 53-56.

Accordingly, it is possible to exchange heat between the high temperature refrigerant, which flows from the refrigerator inlet header 53 into the pair of the refrigerant pipes 22a, and the water inside the water pipe 22b. Consequently, unlike the case wherein, for example, one refrigerant pipe that has been folded into a zigzag and one water pipe are combined, the amount of heat dissipated from the water pipe into the atmosphere is small and virtually no temperature differences arise in the refrigerant on both sides of the water pipe, which makes it possible to obtain high temperature water.

Modified Examples

The text above explains the first embodiment of the present invention, but the present invention is not limited to the above embodiment, and it is understood that variations and modifications may be effected without departing from the spirit and scope of the invention.

1. In the abovementioned embodiment, the water heat exchanger 22 is folded into a zigzag such that its zigs and zags are parallel to one another as shown in FIG. 4, but the present invention is not limited thereto; for example, as shown in FIG. 8, the water heat exchanger 22 may have a spiral shape. Spiral shape refers to a shape wherein, for example, in a water heat exchanger 52 in FIG. 8, linear portions that extend linearly and right angle portions that are bent at right angles alternate repeatedly, the bending directions of the right angle portions are all in the same rotational directions, and the linear portions become shorter as the number of folded locations, namely, the right angle portions, increases. In other words, in the spiral, too, as in the zigzag, the plurality of the linear portions are disposed such that they overlap one another, and thereby a compact structure can be achieved. Furthermore, in the water heat exchanger 52, too, as in the water heat exchanger 22 of the abovementioned embodiment, the refrigerator inlet header 53 is connected to the inlet sides of refrigerant pipes 52a, and the refrigerator outlet header 54 is connected to the outlet sides of the refrigerant pipes 52a, as shown in FIG. 5(a). In addition, in the water heat exchanger 52, as shown in FIG. 5(b), the water inlet header 55 is connected to the inlet side of a water pipe 52b, and the water outlet header 56 is connected to the outlet side of the water pipe 52b.

In addition, because the angle of the folded portion (i.e., the bent part) is larger in the spiral water heat exchanger 52 than in the zigzag water heat exchanger 22, it is possible to minimize any deformation in the thickness directions of each of the flat pipes 41, 42 at the bent parts. Consequently, in the water heat exchanger 52 of the present modified example (1), it is possible to reduce the amount of deformation in the cross sectional shape of each of the flat pipes 41, 42 (particularly the single hole flat pipe 42). Furthermore, in FIG. 8, the refrigerant pipes 52a of the water heat exchanger 52 correspond to the refrigerant pipes 22a of the water heat exchanger 22 in the abovementioned embodiment, and the water pipe 52b of the water heat exchanger 52 corresponds to the water pipe 22b of the water heat exchanger 22 in the abovementioned embodiment.

2. In the abovementioned embodiment, the single hole flat pipe 42 comprises, in a cross section, two linear portions 42a and two curved portions 42b, which connect the two linear portions 42a, but the present invention is not limited thereto; for example, the two portions that connect the two linear portions 42a do not have to be curved. For example, they may be linear portions that are shorter than the two linear portions 42a.

3. In the abovementioned embodiment, the 11 refrigerant passageway holes 47 are arrayed in one row inside the flat part main body 46 of each of the many holed flat pipes 41A, 41B, but the present invention is not limited thereto. For example, the number and arrangement of the holes 47 may be set arbitrarily.

4. In the abovementioned embodiment, the many holed flat pipes 41A, 41B and the single hole flat pipe 42 are joined by brazing, but the present invention is not limited thereto. For example, the surfaces of each of the many holed flat pipes 41A, 41B on the single hole flat pipe 42 side may be coated with an adhesive 50, as shown in FIG. 9, and the members may then be joined together; conversely, the surfaces of the single hole flat pipe 42 on the linear portion sides in a cross section may be coated with the adhesive 50, and the members may then be joined together.

5. In the abovementioned embodiment, as shown in FIG. 4 and like the two linear portions 42a of the single hole flat pipe 42 are disposed such that they are oriented in the horizontal directions, but the present invention is not particularly limited to those directions. For example, the two linear portions 42a may be disposed such that they are oriented in the vertical directions.

6. In the abovementioned embodiment, each of the many holed flat pipes 41A, 41B has a many holed structure wherein the flat pipe is formed into an integral member, but the structure is not limited to an integral member. For example, in FIG. 10, a many holed flat pipe 71A, which is disposed on one of the linear portion side surfaces of the single hole flat pipe 42, comprises two, arrayed many holed flat pipes 71a, 71b, and a many holed flat pipe 71B, which is disposed on the other linear portion side surface of the single hole flat pipe 42, comprises two arrayed many holed flat pipes
71c, 71d. Thus, the many holed flat pipe on one side of the single hole flat pipe 42 may comprise a plurality of many holed flat pipes. In addition, a single many holed flat pipe may be formed by joining multiple capillary tubes together. However, in the case wherein the many holed flat pipe is configured by a plurality of members in this manner, too, it is still possible to prevent the dissipation of heat from the single hole flat pipe 42 to the surrounding air by bringing the many holed flat pipe into tight contact with the two linear portion side surfaces of the single hole flat pipe 42.

(7)

[0097] In the abovementioned embodiment, the single hole flat pipe 42 is formed by extruding or drawing, but the present invention is not limited thereto; for example, as shown in FIGS. 11, 12, protruding parts 81 may be embossed on a flat plate 80 (refer to FIG. 11), after which a single hole flat pipe 82, whose cross section is flat, may be formed. FIG. 11 is a diagram that shows the process of forming the protruding parts 81 by embossing the flat plate 80. In so doing, the plurality of the protruding parts 81 are distributed on the flat plate 80 at fixed intervals. In the present modified example (7), six rows of protruding parts 81a-81f (refer to the portions enclosed by broken lines in FIG. 11) are formed such that they are arrayed in the direction of the water flow. Furthermore, the first row protruding parts 81a through the third row protruding parts 81c are disposed in a first area A1, which forms one of the long side surfaces of the single hole flat pipe 82 in a cross section; furthermore, the fourth row protruding parts 81d through the sixth row protruding parts 81f are disposed in a second area A2, which forms the other long side surface of the single hole flat pipe 82 in a cross section. More specifically, the area of the flat plate 80 from a centerline L1 (refer to the chain line in FIG. 11) in the short side directions to a side 80a (discussed below) is the first area A1, and the area of the flat plate 80 from the centerline L1 to a side 80b (discussed below) is the second area A2.

[0098] The flat plate 80, wherein the protruding parts 81 are formed, is bent into a member 83 such that it is C shaped in a cross section. The member 83, which is C shaped in a cross section, is formed such that the surface of the flat plate 80, wherein the protruding parts 81 are formed, is on the inner side (refer to FIG. 12). FIG. 12 is a diagram that shows the process of forming the single hole flat pipe 82 by bending the flat plate 80, wherein the protruding parts 81 are formed. Furthermore, the uppermost drawing in FIG. 12 is a cross section taken along the XI-XII line of the flat plate 80 in FIG. 11. Both ends of the flat plate 80, namely, the sides 80a, 80b, are mated to one another by bending the flat plate 80 as shown in FIG. 12. The mated side 80a and side 80b on both ends of the flat plate 80 are joined by electro-resistance welding. An electro-resistance welded pipe 84 joined by electro-resistance welding is squashed from both side surfaces such that the electro-resistance welded portion is interspersed therebetween. Furthermore, the single hole flat pipe 82, wherein the first area A1 and the second area A2 of the flat plate 80 are disposed on the long side surfaces of the flat pipe 82 in a cross section such that they oppose one another, is formed.

[0099] The multiple rows of the protruding parts 81a-81f formed in the single hole flat pipe 82 are disposed as described below. The tips of the first row protruding parts 81a disposed in the first area A1 and the tips of the sixth row protruding parts 81f disposed in the second area A2 oppose one another. The tips of the second row protruding parts 81b disposed in the first area A1 and the tips of the fifth row protruding parts 81e disposed in the second area A2 oppose one another. The tips of the third row protruding parts 81c disposed in the first area A1 and the tips of the fourth row protruding parts 81d disposed in the second area A2 oppose one another. Namely, the protruding parts 81a-81f formed in the first area A1 and the protruding parts 81a-81f formed in the second area A2 are disposed at positions at which they mate with one another.

[0100] Thereby, by bending the single hole flat pipe 82, the tips of the protruding parts 81a-81f and the tips of the protruding parts 81a-81f mate with one another even if the single hole flat pipe 82 deforms in the thickness directions. Consequently, it is possible to minimize any deformation and crushing of the single hole flat pipe 82 in the thickness directions. In addition, providing the protruding parts 81 inside the single hole flat pipe 82 produces turbulence in the flow of water, which makes it possible to improve the coefficient of heat transfer.

(8)

[0101] In the modified example (7), the single hole flat pipe 82 has a structure that reduces deformation by the embossing of the flat plate 80, but methods other than embossing can also be used. For example, as shown in FIG. 13, a single hole flat pipe 92 may be formed by bending a flat plate 90. The flat plate 90 is bent in its short side directions, and thereby a member 93 (refer to the drawing in the middle in FIG. 13), whose cross section is B shaped, is formed such that sides 90a, 90b on both ends of the flat plate 90 face the inside of the single hole flat pipe 92. In so doing, portions in the vicinities of the sides 90a, 90b on both ends of the flat plate 90 become support parts 91, which extend along the direction of water flow in the single hole flat pipe 92. Furthermore, in the member 93, whose cross section is B shaped, the single hole flat pipe 92 is formed by pinching the portions at which the support parts 91 are formed and the side surface on the opposite side thereof, and then crushing the member 93, whose cross section is B shaped, from both side surfaces. By performing the fabrication described above, the single hole flat pipe 92, wherein the support parts 91 are formed in order to reduce deformation, may be formed. Furthermore, in this case, the portion at which the two support parts 91 contact one another does not have to be joined by electro-resistance welding and the like, as described in the modified example (7) discussed above. This is because, in this single hole flat pipe 92, even if the process of joining by electro-resistance welding and the like is not performed, the single hole flat pipe 92 is interposed between the many holed flat pipes 41a, 41b and brazed, and thereby the water passageway holes are formed.

[0102] Thus, providing the support parts 91 to the single hole flat pipe 92 makes it possible for the support parts 91 to minimize deformation of the single hole flat pipe 92 even if deformation should occur owing to bending of the single hole flat pipe 92 in its thickness directions. Furthermore, in the modified example (8), the single hole flat pipe 92 has one water passageway hole, but that water passageway hole may be divided into two water passageway holes by the support parts 91. Thus, in a case wherein the support parts 91 divide the water passageway hole into two water passageway holes, the water pipe 22b would become the two holed flat part 92.

(9)

[0103] In modified examples (7), (8), no particular reference is made to whether the material of the flat plates 80, 90 is monolayered or multilayered. However, as shown in FIG. 14, for example, a material that is pre-clad with brazing filler
materials 85b, 95b (i.e., a cladding material), which is an alloy whose melting point is lower than that of base materials 85a, 95a of the flat plates 80, 90, may be used on one surface or both surfaces of the flat plates 80, 90, and thereby the single hole flat pipes 82, 92 may be formed; at least their outer surface sides are clad with the brazing filler materials 85b, 95b. Furthermore, in the many holed flat pipes 41A, 41B shown in FIG. 14, parts that are the same as those in the abovementioned embodiment are assigned the same symbols.

[0104] Thereby, because the material on the outer surface sides of the single hole flat pipes 82, 92 consists of the brazing filler materials 85b, 95b, the outer surface sides can be brazed as in the abovementioned embodiment without separately interposing the brazing filler materials 49 between the single hole flat pipe 42 and each of the many holed flat pipes 41A, 41B. In addition, although not shown, it is also possible to make the structure of the single hole flat pipes 82, 92 such that corrosion owing to water is prevented inside the single hole flat pipes 82, 92 by, for example, coating the inner surface sides of the single hole flat pipes 82, 92 with a coating agent for corrosion prevention or by using a material that has a three-layer structure that incorporates a material resistant to corrosion by water. Furthermore, in FIG. 14, for the sake of explanatory convenience, the protruding parts 81, the support parts 91, and the like are omitted.

[0105] In the abovementioned embodiment, the many holed flat pipes 41A, 41B and the single hole flat pipe 42 are brought into tight contact with one another by hard soldering, wherein the brazing filler materials 49 are interposed between the single hole flat pipe 42 and each of the many holed flat pipes 41A, 41B, after which brazing (i.e., in-furnace brazing) is performed; however, the brazing method is not limited thereto; for example, soft soldering, wherein, for example, solder is used as the brazing filler material, may be performed; furthermore, even in the case of hard soldering, the brazing method may be induction brazing, resistance brazing, atmosphere brazing, vacuum brazing, infrared brazing, pre-placed brazing, aluminum brazing using a high frequency heating apparatus (e.g., ultrasonic soldering), and the like.

<2> Second Embodiment

<Configuration of Hot Water Circulation System>

[0106] FIG. 15 is a schematic block diagram of a hot water circulation system 101 according to a second embodiment of the present invention.

[0107] The hot water circulation system 101 comprises a heat pump circuit 110, a hot water circulation circuit 160, a hot water supply circuit 190, an intermediate pressure water heat exchanger 140, and a high pressure water heat exchanger 150. The hot water circulation system 101 uses the heat obtained by the heat pump circuit 110 not only as the heat for heating via the hot water circulation circuit 160 but also as the heat for supplying hot water via the hot water supply circuit 190. Furthermore, the heat pump circuit 110 is provided to a heat pump apparatus 102, which is a hot water heat source apparatus.

(Water Heat Exchangers)

[0108] The intermediate pressure water heat exchanger 140 and the high pressure water heat exchanger 150 exchange heat between the CO₂ refrigerant, which serves as the primary refrigerant and circulates through the heat pump circuit 110, and the water, which serves as the secondary refrigerant and circulates through the hot water circulation circuit 160. Furthermore, a configuration the same as that of, for example, the water heat exchanger 22 in the first embodiment and the water heat exchanger 52 in the modified example (1) is adopted for the intermediate pressure water heat exchanger 140 and the high pressure water heat exchanger 150.

(Heat Pump Circuit)

[0109] The heat pump circuit 110 uses CO₂ refrigerant, which is a natural refrigerant, as the primary refrigerant. The heat pump circuit 110 comprises a low pressure stage compressor 121, a high pressure stage compressor 125, an economizer heat exchanger 107, an injection passageway 170, a primary refrigerant heat exchanger 108, a primary bypass 150, an expansion valve 105a, an evaporator 104, a fan 104f, and a control unit 111. The evaporator 104 is installed, for example, in the outdoor space.

[0110] The intermediate pressure water heat exchanger 140 is connected to the discharge side of the low pressure stage compressor 121 and the intake side of the high pressure stage compressor 125. In addition, refrigerant piping from the injection passageway 170 (discussed below) joins with the refrigerant piping between a downstream side end part of the intermediate pressure water heat exchanger 140 and the intake side of the high pressure stage compressor 125.

[0111] The high pressure water heat exchanger 150 is connected to the discharge side of the high pressure stage compressor 125 and an upstream side end part in the flow direction of the primary refrigerant that flows toward the expansion valve 105a side via the primary refrigerant heat exchanger 108. The downstream side end part of the economizer heat exchanger 107 in the flow direction of the primary refrigerant that flows toward the expansion valve 105a side is connected to the upstream side end part of the primary refrigerant heat exchanger 108 in the flow direction of the primary refrigerant that flows toward the expansion valve 105a.

[0112] The primary refrigerant heat exchanger 108 exchanges heat between the primary refrigerant that exits the economizer heat exchanger 107 and flows toward the expansion valve 105a and the refrigerant after it has been evaporated by the evaporator 104. Furthermore, in the primary refrigerant heat exchanger 108, the passageway where-through the former refrigerant flows is a primary heat exchange high pressure side passageway 108a, and the passageway where-through the latter refrigerant flows is a primary heat exchange low pressure side passageway 108b. In the primary refrigerant heat exchanger 108, the downstream side end part of the primary heat exchange high pressure side passageway 108a is connected to the expansion valve 105a. In addition, in the primary refrigerant heat exchanger 108, the upstream side end part of the primary heat exchange low pressure side passageway 108b is connected to the downstream side end part of the evaporator 104, and the downstream side end part of the primary heat exchange low pressure side passageway 108b is connected to the intake side of the low pressure stage compressor 121.

[0113] The expansion valve 105a is connected to the upstream side end part of the evaporator 104.

[0114] The downstream side end part of the evaporator 104 is connected to the intake side of the low pressure stage compressor 121 via the primary heat exchange low pressure side passageway 108b of the primary refrigerant heat exchanger 108.
[0115] The injection passageway 170 is a refrigerant piping that branches from the refrigerant piping between the refrigerant piping downstream side end part of the high pressure water heat exchanger 105 and the economizer heat exchanger 107. The injection passageway 170 comprises an injection expansion valve 173. The economizer heat exchanger 107 exchanges heat between the refrigerant that flows through the injection passageway 170 and whose pressure is reduced by the injection expansion valve 173 and the refrigerant whose heat was dissipated by the high pressure water heat exchanger 105. Namely, after the pressure of the refrigerant that flows through the injection passageway 170 is reduced by the injection expansion valve 173, the economizer heat exchanger 107 exchanges heat between that refrigerant and the refrigerant on the high pressure side, and that refrigerant then merges with the intake side of the high pressure stage compressor 125.

[0116] Thus, in the heat pump circuit 110, the adoption of the injection passageway 170 makes it possible to improve the coefficient of performance of the heat pump circuit 110. Furthermore, if, for example, the heating load is small and therefore even if a cooling effect of the primary refrigerant sufficient to improve the efficiency of the heat pump circuit 110 cannot be obtained in the intermediate pressure water heat exchanger 140, operation efficiency can be improved by increasing the amount of injection passing through the injection passageway 170. Furthermore, in the heat pump circuit 110, the injection passageway 170 joins the passageway between the intermediate pressure water heat exchanger 140 and the high pressure stage compressor 125, and consequently the high temperature primary refrigerant discharged from the low pressure stage compressor 121 can be supplied to, without being cooled prior to reaching, the intermediate pressure water heat exchanger 140, thereby maintaining the high temperature state as is. Consequently, the temperature of the water for heating that passes through the intermediate pressure water heat exchanger 140 can be made sufficiently high.

[0117] The primary bypass 180 functions as a bypass between the refrigerant piping that is between the downstream side end part of the economizer heat exchanger 107 and the upstream side end part of the primary heat exchange high pressure side passageway 108a of the primary refrigerant heat exchanger 108 and the refrigerant piping that is between the expansion valve 105a and the upstream side end part of the evaporator 104. A primary bypass expansion valve 105b is provided to the primary bypass 180.

[0118] Thus, because the primary bypass expansion valve 105b is provided to the primary bypass 180, the control unit 111 can regulate the amount of the primary refrigerant that passes through on the primary refrigerant heat exchanger 108 side. Consequently, the primary refrigerant taken in by the low pressure stage compressor 121 can be regulated such that the primary refrigerant has an appropriate degree of superheating. Specifically, if the control unit 111 reduces the valve opening degree of the primary bypass expansion valve 105b, the flow volume of the primary refrigerant that passes through the primary refrigerant heat exchanger 108 will increase, which makes it possible to increase the degree of superheating of the primary refrigerant taken in by the low pressure stage compressor 121; thereby, it is possible to reduce the compression ratio needed to make the discharge refrigerant temperature of the low pressure stage compressor 121 reach the target temperature. In addition, if the control unit 111 increases the valve opening degree of the primary bypass expansion valve 105b, then the flow volume of the primary refrigerant that passes through the primary refrigerant heat exchanger 108 will decrease, which makes it possible to reduce the degree of superheating of the primary refrigerant taken in by the low pressure stage compressor 121; thereby, it is possible to avoid the situation wherein the density of the refrigerant taken into the low pressure stage compressor 121 decreases markedly, making it impossible to ensure the required amount of circulation.

[0119] Based on values detected by various sensors (not shown) and the like, the control unit 111 controls the low pressure stage compressor 121, the high pressure stage compressor 125, the injection expansion valve 173, the expansion valve 105a, the primary bypass expansion valve 105b, the fan 140/ and the like.

(Hot Water Circulation Circuit)

[0120] Water, which serves as the secondary refrigerant, circulates in the hot water circulation circuit 160. The hot water circulation circuit 160 comprises radiators 161, a hot water pump 163, a hot water mixing valve 164, a hot water feed pipe 165, a hot water return pipe 166, an intermediate pressure side branch passageway 167, a high pressure side branch passageway 168, a hot water storage tank 191, a hot water branching valve 192, and a hot water supply side branch passageway 195.

[0121] The hot water branching valve 192 divides the flow of the hot water heated by the intermediate pressure water heat exchanger 140 or the high pressure water heat exchanger 150 between the radiators 161 and the hot water storage tank 191 in accordance with their thermal loads.

[0122] The radiators 161 are installed in the space to be heated, and heating is performed by warming the air of the target space using the flow of the warm water, which serves as the secondary refrigerant, inside the target space. Although not shown, each of the radiators 161 has a feed port, which is for receiving the warm water delivered from the hot water pump 163, and a return port, which is for delivering the water after its heat has been dissipated in the radiator 161 to the intermediate pressure water heat exchanger 140 and the high pressure water heat exchanger 150. The hot water return pipe 166 is connected to the return port of each of the radiators 161.

[0123] A hot water supply heat exchanging part 191a inside the hot water storage tank 191 exchanges heat between the water flowed from the hot water supply side branch passageway 195 and the water for the hot water supply stored inside the hot water storage tank 191, and heat is dissipated by the heating of the water for the hot water supply. The hot water return pipe 166 is connected to a circulation return port of the hot water storage tank 191, and the water whose heat was dissipated by the hot water supply heat exchanging part 191a merges with the water in the hot water return pipe 166. Here, although not shown, a circulation feed port and a circulation return port are provided to the hot water storage tank 191.

[0124] In the hot water return pipe 166, the water whose heat has been dissipated in the radiators 161 or the hot water storage tank 191 is diverged to the intermediate pressure side branch passageway 167, which delivers the water to the intermediate pressure water heat exchanger 140 side, and the high pressure side branch passageway 168, which delivers the water to the high pressure water heat exchanger 150 side.

[0125] In the hot water storage tank 191, room temperature water delivered from an external municipal water service (not shown) via a water supply pipe 194 is supplied from the
vicinity of a lower end part of the hot water storage tank 191 to the interior of the hot water storage tank 191.

[0126] A hot water supply pipe 198 guides the hot water that has accumulated inside the hot water storage tank 191 from the vicinity of an upper end part of the hot water storage tank 191 to the location at which it is to be used (not shown). The hot water supply pipe 198 directs the flow from the hot water storage tank 191 toward the location at which it is used. In the water supply pipe 194, the flow toward the hot water storage tank 191 is diverged by a hot water supply bypass pipe 199. The hot water supply bypass pipe 199 is connected to a hot water supply mixing valve 193, whereeto the hot water supply pipe 198 is provided. The hot water supply mixing valve 193 can regulate the mixing ratio between the hot water that is delivered from the hot water storage tank 191 via the hot water supply pipe 198 and the room temperature water that is supplied from the municipal water service via the hot water supply bypass pipe 199. The temperature of the water delivered to the usage location is regulated by the hot water supply mixing valve 193 regulating the mixing ratio.

[0127] The water diverged to the intermediate pressure side branch passageway 167 is heated by the intermediate pressure water heat exchanger 140 exchanging heat between that water and the CO₂ refrigerant, which is the primary refrigerant, after which that water merges with the water in the hot water feed pipe 165 via the hot water mixing valve 164. Here, in the intermediate pressure water heat exchanger 140, the CO₂ refrigerant, which serves as the primary refrigerant, and the water, which serves as the secondary refrigerant for heating and hot water supply, flow in mutually opposing directions.

[0128] The water diverged to the high pressure side branch passageway 168 is heated by the high pressure water heat exchanger 150 exchanging heat between that water and the CO₂ refrigerant, which is the primary refrigerant, after which that water merges with the water in the hot water feed pipe 165 via the hot water mixing valve 164. Here, in the high pressure water heat exchanger 150, the CO₂ refrigerant, which serves as the primary refrigerant, and the water, which serves as the secondary refrigerant for heating and hot water supply, flow in mutually opposing directions.

[0129] Furthermore, based on, for example, the temperature detected by the various sensors and the like, the control unit 111 controls the diverging ratio of the hot water mixing valve 164 and the flow volume of the hot water pump 163, or controls the diverging ratio of the hot water branching valve 192 such that secondary refrigerant of the required temperature can be supplied to the radiators 161.

<Characteristics>

[0130] Unlike the first embodiment, the intermediate pressure water heat exchanger 140 and the high pressure water heat exchanger 150 according to the second embodiment are used in a closed circuit, wherefore water circulates as the secondary refrigerant. Consequently, mixing a corrosion prevention agent into the water that circulates as the secondary refrigerant makes it possible to prevent corrosion of the water heat exchangers 22, 52 (particularly the water pipes 22b, 52b), even if the inner surfaces of the water pipes 22b, 52b in particular do not undergo a corrosion prevention process.

INDUSTRIAL APPLICABILITY

[0131] The water heat exchanger according to the present invention is used as a water heat exchanger that can prevent a decrease in heat exchanging efficiency, can be configured simply, and can exchange heat between a refrigerant and water.

REFERENCE SIGNS LIST

[0132] 2 Refrigeration apparatus
[0133] 20 Refrigerant circuit
[0134] 21 Compressor
[0135] 22, 52 Water heat exchangers
[0136] 22a, 52a Refrigerant pipes
[0137] 22b, 52b Water pipes
[0138] 23 Expansion valve (expansion mechanism)
[0139] 24 Air heat exchanger (evaporator)
[0140] 41A, 41B, 71A, 71B Many holed flat pipes
[0141] 42, 82, 92 Single hole flat pipes (sparely holed flat pipes)
[0142] 47 Refrigerant passageway hole
[0143] 48 Water passageway hole
[0144] 49 Brazing filler material
[0145] 50 Adhesive
[0146] 53 Refrigerant inlet header
[0147] 54 Refrigerant outlet header
[0148] 55 Water inlet header
[0149] 56 Water outlet header
[0150] 80, 90 Flat plates
[0151] 80a, 80b Sides on both ends (two sides)
[0152] 102 Heat pump apparatus
[0153] 104 Evaporator
[0154] 105a Expansion valve (expansion mechanism)
[0155] 105b Primary bypass expansion valve (expansion mechanism)
[0156] 110 Heat pump circuit (refrigerant circuit)
[0157] 121 Low pressure stage compressor (compressor)
[0158] 125 High pressure stage compressor (compressor)
[0159] 140 Intermediate pressure water heat exchanger (water heat exchanger)
[0160] 150 High pressure water heat exchanger (water heat exchanger)

Citation List

Patent Literature

Patent Document 1


1. A water heat exchanger configured to exchange heat between a refrigerant and water, the water heat exchanger comprising:
a pair of flat refrigerant pipes, each flat refrigerant pipe having a plurality of refrigerant passageway holes arranged to have the refrigerant flow therethrough; and a flat water pipe having at least one water passageway hole arranged to have the water flow therethrough, the number of water passage holes being fewer than the number of refrigerant passageway holes of the flat refrigerant pipes,
long side surfaces of the flat water pipe and a long side surface of each of the pair of flat refrigerant pipes are in tight contact with each other as viewed in cross section, and the flat water pipe being interposed by the pair of flat refrigerant pipes.
2. The water heat exchanger according to claim 1, wherein the number of the water passageway holes of the flat water pipe is one or two.

3. The water heat exchanger according to claim 1, wherein the flat water pipe is joined to each of the pair of flat refrigerant pipes by brazing using a brazing filler material or by adhesives.

4. The water heat exchanger according to claim 1, wherein at least one of the flat refrigerant pipes and the flat water pipe is formed by drawing or extruding.

5. The water heat exchanger according to claim 1, wherein the flat water pipe is formed by bending a flat plate.

6. The water heat exchanger according to claim 5, wherein the flat water pipe is an electro-resistance welded pipe formed by bringing two sides of the flat plate into contact by the bending, and then joining the two sides.

7. The water heat exchanger according to claim 5, wherein the flat plate is embossed prior to the bending.

8. The water heat exchanger according to claim 1, wherein the refrigerant that flows through an interior of the flat refrigerant pipes and the water that flows through an interior of the flat water pipe flow in mutually opposing directions.

9. The water heat exchanger according to claim 1, wherein the refrigerant is CO₂.

10. A hot water heat source apparatus configured to be used with a refrigerant circuit using a supercritical refrigerant, a high pressure side of a refrigeration cycle being in a supercritical region in the refrigerant circuit, the hot water heat source apparatus comprising:
    a compressor arranged to compress the supercritical refrigerant;
    a water heat exchanger arranged to cool the supercritical refrigerant and to heat water by exchanging heat between the water and the high temperature and high pressure supercritical refrigerant compressed by the compressor;
    an expansion mechanism arranged to reduce pressure of the supercritical refrigerant cooled by the water heat exchanger; and
    an evaporator arranged to evaporate the refrigerant whose pressure was reduced by the expansion mechanism, the water heat exchanger including
    a pair of flat refrigerant pipes, each refrigerant pipe having a plurality of refrigerant passageway holes arranged to have the refrigerant flow therethrough, and
    a flat water pipe having at least one water passageway hole arranged to have the water flow therethrough, the number of water passage holes being fewer than the number of the refrigerant passageway holes of the flat refrigerant pipes;
    a refrigerant inlet header having inlets of the pair of flat refrigerant pipes connected thereto; and
    a refrigerant outlet header having outlets of the pair of flat refrigerant pipes connected thereto,
    long side surfaces of the flat water pipe and a long side surface of each of the pair of flat refrigerant pipes are in tight contact with each other as viewed in cross section,
    the flat water pipe being interposed by the pair of flat refrigerant pipes, and
    the refrigerant that flows through an interior of the flat refrigerant pipes and the water that flows through an interior of the flat water pipe flowing in mutually opposing directions.

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